Cost and Performance Report

Advanced Site Technology Deployment

Surface Contamination Monitor And Survey Information Management System

U.S. Department of Energy

Nevada Operations Office &
EM/Office of Science and Technology

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
ASTD	Accelerated Site Technology Deployment
CAD	Computer-aided design
CFR	*Code of Federal Regulations*
cpm	Counts per minute
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energ
DOE/NV	U.S. Department of Energy, Nevada Operations Office
dpa	Disintegrations per area
dpm	Disintegrations per minute
EM	Environmental Management
E-MAD	Engine-Maintenance, Assembly, and Disassembl
EPA	U.S. Environmental Protection Agenc
ETS-1	Engine Test Stand-1
FIDLER	Field instrumentation detection for low energy radiation
ITLV	IT Corporation, Las Vegas
MARSSIM	Multi-Agency Radiation Surve and Site Investigation Manual
MSI	Millenium Services, Inc.
NRDS	Nuclear Rocket Development Station
NTS	Nevada Test Site
NIST	National Institute of Standards and Technolog
PC	Personal computer
PSPC	Position-sensitive proportional counter
PSRM	Position-sensitive Radiation Monitor
R-MAD	Reactor-Maintenance, Assembly, and Disassembl
SCM	Surface Contamination Monitor
SIMS	Survey Information Management System
SRA	Shonka Research Associates, Inc.
VAC	Volts, alternating current

1.0 SUMMARY

1.1 Background

Surveying surfaces for alpha, beta, and gamma contamination and documenting results remain major challenges for most decontamination projects. The baseline technology, using "handheld" instruments and manual mapping of results, is labor intensive, relatively slow, and subject to human error. Automated surveying systems that record and display data as collected coupled with post-survey computer processing of the collected data enhances survey, efficiency, reliability, and reduces costs.

1.2 Site Information

To address the site's need, the U.S Department of Energy's (DOE) Environmental Management (EM) Office of Science and Technology (EM-50) partnered with the DOE Nevada Operations Office (DOE/NV) in an Accelerated Site Technology Deployment (ASTD) project with EM-50 providing $85K of funding. DOE/NV committed an additional $85k to the ASTD project. Through this activity, the Nevada Test Site (NTS) contracted for survey services to deploy the Surface Contamination Monitor and Survey Information Management System (SCM/SIMS) developed b Shonka Research Associates (SRA) and operated by Millennium Services, Inc. (MSI). The SCM/SIMS was deployed at three NTS facilities for the characterization of concrete pads in order to expedite survey, characterization, and closure at a reduced cost and risk. Use of SCM/SIMS was beneficial in characterizing the facilities. The technology has the potential to be used at other NTS facilities in either characterization or final release survey mode.

1.3 Site Application

The Shonka Position-Sensitive Radiation Monitor (PSRM) system has been demonstrated at both the Hanford 105-C reactor and the Argonne National Laboratory CP-5 reactor and has been deployed at the Rocky Flats Environmental Technology Sites. Five facilities at the NTS are slated for decontamination and decommissioning (D&D) in the next seven years. The first facilities to be surveyed for D&D are in Area 25, where nuclear rocket development took place. The site needs a monitor for alpha, beta, and gamma scanning of large pads or floors at these facilities.

Figure 1-1 Surface Contamination Monitor

1.4 System Description

The PSRM consists of a cart mounted surface contamination monitor (SCM) and a surve information management system (SIMS) as shown in Figure 1-1. The SCM consists of a position-sensitive proportional counter that acts as the equivalent of hundreds of individual detectors aligned in either a 90-centimeter (cm) or 180-cm long detector row. Using a low-cost wheel encoder, the detector scans over the surface in a series of 90-cm or 180-cm wide strips. The cart drive-motor speed along with the wheel encoder can be calibrated such that when a survey starts the system automatically records the radiological and location information.

The SIMS includes an electronic datalogger and a personal computer (PC). The SIMS records both the intensity and location of the radioactivity in an electronic database and mapping software. The data are downloaded to a PC that stores all the information in binary files that can be analyzed by the software system for report generation and re-examination. The system removes the technician's subjective observations from the process and produces more understandable reports of the radiological conditions. These reports can be graphical, with color-coded radiological levels overlaid on a computer-aided design (CAD) drawing or on a digital photograph of the surface being surveyed. This system is also capable of producing 2-dimensional and pseudo 3-dimensional surface plots of hot spot locations and the associated radiological measurements in units of counts per minute (cpm) (or efficienc -corrected units of disintegrations per minute [dpm]). The system can be equipped with a variety of sensors to facilitate the detection of both alpha and beta/gamma radiation fields.

1.5 System Performance and Benefits

The SCM/SIMS correlates survey data with the surface location and a software program automatically generates survey reports. Color-coded 2- and 3-dimensional graphics are can be generated and overlaid on drawings or photographs of the site giving managers and technicians a more complete understanding of the contaminated area, thus optimizing remedial planning. Benefits include:

- SCM/SIMS displays to the operator the minimum, max imum, average, and standard deviation of the survey data in real time. Measurements exceeding regulatory results can be set to appear as either color-coded or in boldface type.
- SCM/SIMS takes 400 measurements per square meter with a minimum detectable activity that is significantly improved for detecting hot spots over the baseline technology. This provides a higher confidence in the completeness and sensitivit of the radiological survey.
- SCM/SIMS consistently maintains the proper survey speed and distance between the detector and monitor surface, allowing for 100 percent coverage while significantly reducing the variation and uncertainty in the survey data.

1.6 System Cost

SCM/SIMS has proven cost and productivity rates that are superior to the conventional baseline methods. As part of the Hanford C -Reactor Large Scale Demonstration and Deployment Project, SCM/SIMS had productivity rates five times faster for beta/gamma surveys and two times faster for alpha surveys. The cost of the system was 13 to 57 percent lower than the baseline.

In this deployment, the SCM/SIMS proved to be superior to the conventional, handheld approach from a productivity and cost standpoint. The handheld method requires approximately one hour per square meter of surface surveyed. The handheld method would have required approximately 3,735 hours (all work elements) to survey the 3,735 square meters at the Test Cell C pad, the Reactor-Maintenance, Assembly, and Disassembly (R-MAD) Decontamination Building floor, and the Engine Test Stand (ETS-1). The 3,735 square meters were surveyed using the SCM/SIMS in approximately 110 survey hours. The use of the SCM/SIMS demonstrated a 25 to

34-fold increase in efficiency (surveying only) over the handheld methodology. The total cost for performing the survey using the handheld methodology on all 3,735 square meters was calculated to be about $162,000. The total cost for the use of the SCM/SIMS for the same survey was about $115k. Implementing the SCM/SIMS resulted in a cost saving of 40 p ercent over the handheld method.

1.7 Regulatory/Institutional Issues

The SCM/SIMS system is an investigation tool for characterizing contaminated surfaces; therefore, no special regulatory permits are required for its use. The detection level of the SCM/SIMS system meets the requirements of 10 *Code of Federal Regulations* (CFR) Part 20 and proposed Part 834, which makes this system appropriate for free-release surveys.

1.8 Schedule

Both the proposed and the actual schedule for this ASTD are shown below for comparison.

ACTIVITY	PROPOSED SCHEDULE	ACTUA PERFORMANCE
Procurement	June 1999	September 1999
Training	September 1999	October 1999
First Deployment	October 1999	October 20, 1999
Second Deployment	December 1999	October 27, 1999
Survey Report	April 2000	April 2000
Evaluation Report	June 2000	June 2000

1.9 Observations and Lessons Learned

There were a number of lessons learned identified during the deployment at NTS including the following:

- Site preparation – All surfaces to be surveyed require complete removal of small rocks, weeds, and surface debris and the surfaces should be swept prior to starting surveys. Surface preparation increases survey speed and reduces the potential for detector damage however, the increased exposure potential from airborne contaminates due to sweeping should be considered.

- Starting location – The radiation monitoring should be started in the area that potentially has the highest contamination levels first. This provides timely health and safety information and ensures contamination levels are as expected.

- Cart design – The SCM-4 cart with the capabilities to survey walls as well as floors and pads created some difficulty in keeping the detectors flush to the surface particularly on flat surfaces. The SCM-1 cart design would improve survey speed and reduce measurement errors from the detector coming up off the ground for horizontal surveys.

- Calibration sources – Large area National Institute of Standards and Technology (NIST) traceable sources would provide enhanced calibration for the PSRM.

- Handheld instruments – The use of the PSRM requires handheld instruments to support locating and marking hot spots identified by the PSRM. The continuous survey provided by the PSRM does not allow time for the operator to identify the exact location of contamination. Some additional development of a mechanism to mark hot spots detected during the survey would enhance the process of pinpointing the location for cleanup during remediation.

- Data reports – The automatically generated survey reports generated by the SIMS are significant to the efficiency of the technology as deployed at NTS. The automatically generated surve reports did not clearly identify the type of survey being represented (e.g., alpha or beta survey). The survey report falsely indicates 0 dpm per100 cm minimum surface activity for the surve area when incomplete survey grids are included. This was manually correlated during data analysis.

- Topology – Application may be limited on floors or pads with curvature or uneven surfaces. Pads that are not flat but curved do not allow constant distance between the detectors and the surface being surveyed.

2.0 SITE INFORMATION

2.1 Nevada Test Site History

The NTS occupies 1,570 square miles in southern Nevada and is located approximately 65 miles northwest of Las Vegas. The NTS was selected for the Rover program as the location to test nuclear rocket engines. The tests were performed in the southwest corner (Area 25) of NTS in an area designated as the Nuclear Rocket Development Station (NRDS). The NRDS consisted of three test cells (designated as "A", "C" and ETS -1); R-MAD and Engine Maintenance, Assembly, and Disassembly (E-MAD); a Control Point/Technical Operations complex; an administrative area; and a radioactive material storage area. A destructive test, the KIWI Transient Nuclear Test, was conducted on a separate pad adjoining Test Cell C. Test Cells A and C and R -MAD are among the five NTS facilities contaminated as a result of past operations that will likely require radiation surveys as part of D&D activities.

2.2 Identifying Information

The SCM/SIMS was deployed at Test Cell C, the R -MAD decontamination building, and ETS -1 to characterize these areas in preparation for future D&D. Test Cell C has an outdoor pad where nuclear rocket engines were tested. Other areas at Test Cell C may also be surveyed using the SCM/SIMS. The focus of this report is the initial deployment of the technology at Test Cell C, R-MAD Decontamination Building, and ETS-1.

2.3 Technology Application

The SCM/SIMS technology was selected for its capability to survey large flat surfaces quickly and efficiently. In this application, it was used to characterize a large, exterior concrete pad that is part of Test Cell C. The baseline technology planned for use at the NTS was handheld radiation surveys. The SCM/SIMS technology can provide well-documented characterization or release surveys of contaminated or potentially contaminated floors, pads, portions of building including walls and ceilings, and other structural components before and after D&D. The system is particularly suited to smooth surfaces. Since a protective window is used, rough surfaces may damage the window resulting in either reduced detector sensitivity or increased maintenance. Caution is advised when deploying this technology to areas where surfaces are rough or where there is debris that could damage the detector windows. **The precision and quality of the survey documents resulting fro use of this technology support regulatory reviews.** A full description of the detection and monitoring system is provided in Section 4.0.

2.4 Contacts:

Management:
Clayton Barrow, DOE/NV, (702) 295-7960, e-mail barrow@nv.doe.gov
Robert Eastmond, IT Corporation, (702) 295-2203, e-mail reastmon_it@nv.doe.gov
John Duda, DOE, NETL, (304) 285-4217, e-mail John.Duda@netl.doe.gov

Technical Information:
Joseph Shonka, SRA, (770) 509-7606

Licensing:
Debby Shonka, SRA, (770) 509-7606

3.0 SITE APPLICATION

3.1 Survey Area Description

Surveys were performed at the large concrete pad where the rocket engines were operated at the north end of Test Cell C. The original concrete pad is located next to the building as well as an extension to the pad located to the north of and adjoining the original pad. There are trenches in the pad that formerly contained rails for positioning the engine and weather shield. The concrete had significant vegetation growth in some of the joints and cracks. Although some surface preparation had been performed, residual vegetative stubble prevented effective surveying with either handheld instrumentation or the SCM without careful removal of plant materials. Figure 3-1 is a photograph of the site showing part of the area surveyed. There are drains located at various places in the pad to control runoff from the surface. These drains could not be effectively surveyed for alpha, due to the distance from the detector to the surface. Since little alpha was found at Test Cell C, a follow-up survey with handheld instrumentation is not required. Because of the high energy of the beta contamination, the beta survey of the drains is sufficient, although the maximum values noted for localized contamination may be slightly understated. The beta concentration data is summarized in this report. Areas of the concrete appeared to have a surface coating. Alpha contamination beneath the surface coating can not be measured with gross contamination surface measurements.

Figure 3-1 Test Cell C and associated concrete pad area.

3.2 Surveys

3.2.1 Monitoring Equipment and Methods

Surveys were conducted us ing SCM (Model SCM4) manufactured by SRA. See Figure 3-1A. The system consists of a PSPC coupled to a computerized data acquisition system. The PSPC is a long detector that acts as an array of many small radiation detectors. This allows the instrument to measure more area per unit time than a smaller detector and still separate out localized areas of contamination. The PSPC is mounted to a motor driven cart. The drive motor provides speed control for the unit, and a precision wheel encoder, affixed to t he cart, provides travel distance input to the computer. Counts are accumulated in each 5 cm channel for every 5 cm traveled by the system. The result is data retained in 5 cm x 5 cm pixels, available for analysis and presentation via the SIMS software.

Figure 3-1A SRA's Surface Contamination Monitor (SCM) on waste pad.

Three PSPCs were used for the surveys at NTS. Two lengths (180 cm and 90 cm) were available for the cart mounted rolling surveys, and one length (180 cm) was available for fixed cou nts. The SCM can be used in a mode in which a series of side-by-side static (nonrolling) counts are taken for a short period of time to cover an area. This is used in areas, such as trenches, where the cart cannot roll. Surveys were conducted in accord ance with equipment operation and calibration procedures developed by SRA.

3.2.2 Reporting Criteria

The criteria for reporting the surface contamination are provided in Table 3 -1. The same criteria are provided in 10 CFR 835 as well as DOE Order 5400.5 f or beta contamination. The alpha limits assumed are 20 percent of the applicable limit for uranium. The maximum -recorded reading (106 μR/hr) during the survey was below requirements for posting as a radiation area. Results from the SCM are reported in gross dpm, and background must be added to the reporting criteria listed below.

Table 3-1 Reporting Criteria used for Survey Reports

Type of Radiation	Average net dp per 100 cm^2	Maximum net dpm per 100 cm^2
Surface Beta	5,000	15,000
Surface Alpha	1,000	3,000

dpm = disintegrations per minute
cm^2 = square centimeters

3.2.3 Beta Background

The backgrounds used for this survey took advantage of the capability of the SCM to measure the entire surface under study. When the entire surface is measured, background can be established from uncontaminated surface areas within the surface being surveyed. A statistical evaluation is used to separate any contaminated areas from uncontaminated areas.

The beta background for the surface is then established in an iterative fashion. The data used to establish the beta background is acquired only from square meter areas that meet the following three criteria. Only the data acquired from a full square meter of surveyed surface is used to compute the beta background concentration. The data is rejected for establishing background if the square meter of area contains a value exceeding one-half of the reporting limit. This is done to assure that a one square meter area containing localized spots of contamination is not selected. Finally, the data is rejected for use in establishing background if the beta count rate from the one square meter area has a standard deviation that exceeds one -half of the reporting criteria. This criterion assures that areas with a high degree of variability are not used to establish background. The cumulative frequenc distribution of the average beta count rate for each square meter is evaluated. If the beta count rate data is normally distributed, the mean of the distribution is used as the beta background.

The data indicated that the average background for Test Cell C was 3860 $\pm$ 280 disintegrations per area (dpa) (Table 3-2). This value is used for assessing whether contamination is present. The computer-generated reports of the beta survey at Cell C add this background to the reporting criteria to establish what areas are above the limits called for.

Table 3-2 Backgrounds Levels

Area	Alpha (dpa)	Beta (dpa)
C Cell	0	3859
RMAD	0	3677
ETS-1	0	3104

dpa = disintegrations per area

3.2.4 Alpha Background

Because the backgrounds are extremely low for alpha radiation, and because this survey did require the low-level reporting criteria for contamination from transuranic nuclides, a background of zero was assumed for the gross alph a contamination measurements. This means that the reporting of contamination over the limits (either 1,000 average dpa or 3,000 maximum dpa) would be conservative, since background was not considered. Alpha backgrounds are typically between 10 and

100 dpa, so contamination present at just under 1,000 average dpa would have improperly been determined to be over the limit, which would not be true if the small background had been considered.

3.3 Beta Survey Results

The characterization results are provide d in summary form in this report. The results of the surveys using the SCM/SIMS technology are provided in computer generated reports in both tabular and graphic formats. For purposes of this document, the surface contamination measurements are presented in graphic, CAD overlay, and summary table.

3.3.1 Beta Surveys at Test Cell C.

Figure 3-2 provides a CAD drawing of Test Cell C with the survey data superimposed as a two - dimensional color image. Table 3 -3 summarizes the data from Test Cell C. There were a total of 3,372 full or partial square meter areas surveyed. There were 1,101 of these areas found to be in excess of the average reporting criteria. Also, 1,132 of these areas had localized contamination in excess of the localized area-reporting limit.

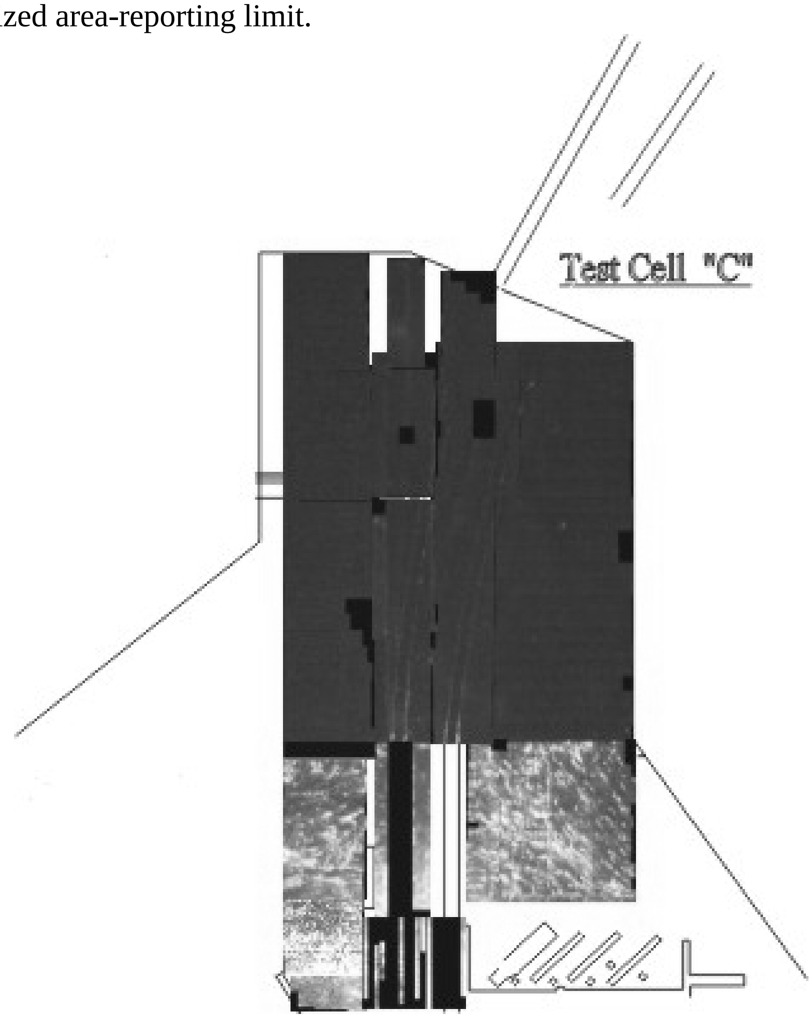

Figure 3-2 Overlay of Survey Results on Test Cell C Site Drawing

Table 3-3 Beta Survey Summary: Test Cell C

Survey Area	**Maximum Concentration in any 100 cm^2 (dpm/100 c ^{2})**	**Area (^{2})**	**Number of m^2 Exceeding Limit**	**Number of 100 cm^2 Areas Exceeding Limit**	**PSPC Efficiency**
CELLC01B	57,187	210	0	1	0.29
CELLC02B	22,603	260	0	1	0.29
CELLC03B	15,464	241	0	0	0.29
CELLC04B	320,161	260	258	253	0.29
CELLC05B	300,099	169	169	169	0.29
CELLC06B	223,083	118	116	116	0.29
CELLC07B	64,213	102	5	9	0.29
CELLC08B	16,182	112	0	0	0.29
CELLC09B	25,899	164	0	2	0.29
CELLC10B	16,131	145	0	0	0.29
CELLC11B	21,638	73	0	2	0.29
CELLC12B	16,962	117	0	0	0.29
CELLC13B	58,764	111	0	5	0.29
CELLC14B	103,086	108	11	25	0.29
CELLC15B	133,701	113	112	110	0.29
CELLC16B	464,410	95	88	95	0.31
CELLC17B	118,892	31	31	31	0.29
CELLC18B	145,310	111	111	111	0.29
CELLC19B	165,851	200	200	200	0.29
CELLC20B	23,641	151	0	2	0.29
CELLC21B	15,264	150	0	0	0.29
CELLC22B	12,854	151	0	0	0.29
CELLC23B	9,560	180	0	0	0.29

dpm = disintegrations per minute
cm^2 = square centimeters
m^2 = square meters

The data can be subjected to further study using SIMS. For example, Figure 3-3 shows the railroad tracks where there is sufficient activity to be seen as an artifact in the beta contamination measurement.

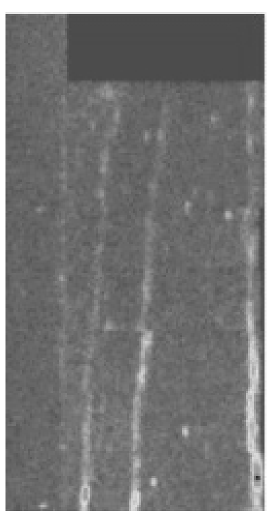

Figure 3-3 Beta Activity near Railroad Tracks at Test Cell C

The beta contamination data collected at Test Cell C is displayed in a three-dimensional perspective in Figure 3-4.

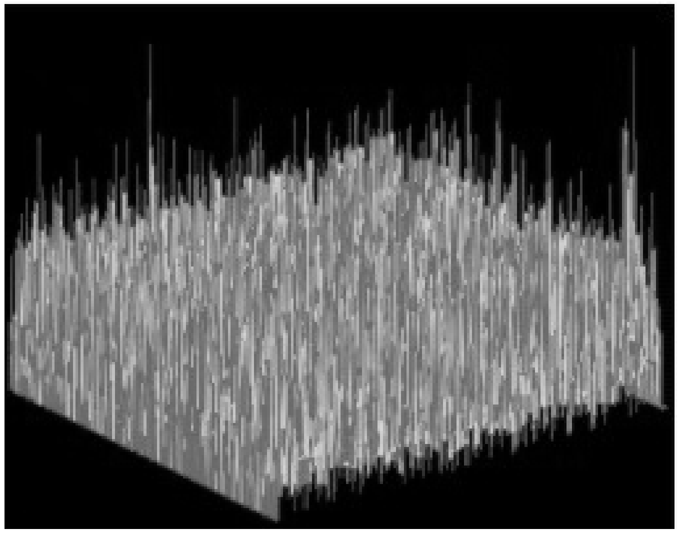

Figure 3-4 A 3-Dimensional Image of the Beta Contamination from a Section of the Test Cell C Pad

Figure 3-5 is the same beta contamination data as shown in Figure 3-4, with the data modified (treated) with weiner filtering using SIMS. The weiner filter is an adaptive filter that averages the contamination using an area for averaging whose size is inversely proportional to the standard deviation of the data. This filter reduces the apparent noise (or variability of background) in the image and shows the peaks of contamination more clearly, while preserving the maximum data.

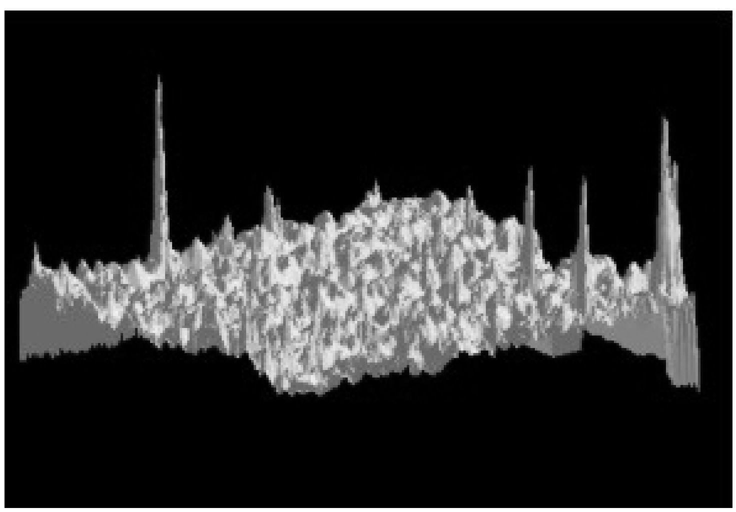

Figure 3-5 Filtered 3-Dimensional View of Test Cell C Data

The image in Figure 3-6 uses SIMS to modify the color map and scale. This presentation of the data permits the user to more easily see the elevated areas of contamination.

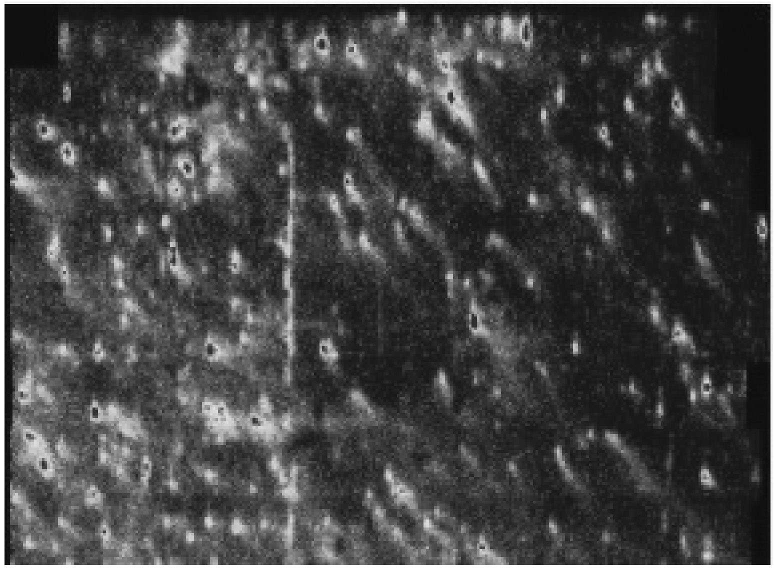

Figure 3-6 Enhanced 2-Dimensional View of Test Cell C Data

3.3.2 Beta Surveys at R-MAD

The R-MAD Decontamination Building is shown in Figure 3 -7. The survey of the R-MAD area consisted of 6 survey zones with a total of 313 full and partial square -meter areas. Figure 3-8 overlays the survey data on top of the site CAD drawing. Table 3 -4 provides a summary of the survey results. Of the 313 full and partial square meters, 245 had more than one -half of the square meter area measured using the SCM. There were 35 areas with no evidence of contamination, and 210 areas with activity dispersed on them. Of the 210 contaminated meters, 196 were above the meter average reporting criteria (5,000 dpa), and 193 of the 210 meters had elevated hot spots that were above the maximum reporting criteria (15,000 dpa).

Figure 3-7 R-MAD Decontamination Building

The spatial distribution of contamination is shown in the composite image (Figure 3-8). Table 3-4 summarizes the beta concentration measurements.

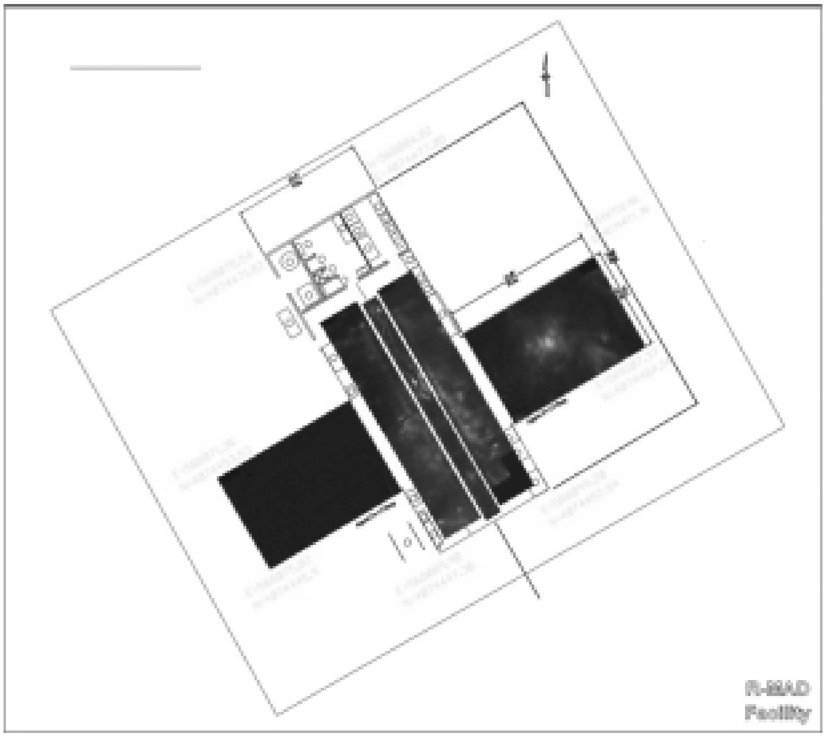

Figure 3-8 Overlay of Survey Results on R-MAD Site Drawing

Table 3-4 Beta Survey Summary: R-MAD

Survey Area	**Maximum Concentration in any 100 cm^2 (dpm/100 c ^{2})**	**Area (^{2})**	**Number of m^2 Exceeding Limit**	**Number of 100 cm^2 Areas Exceeding Limit**	**PSPC Efficiency**
RMAD1B	28,011	75	0	1	0.29
RMAD2B	195,512	64	63	62	0.29
RMAD3B	219,427	75	50	46	0.29
RMAD4B	156,562	66	50	51	0.29
RMAD2	278,371	18	18	18	0.43
RMAD4BB	537,686	15	15	15	0.43

dpm = disintegrations per minute
cm^2 = square centimeters
m^2 = square meters

3.3.3 Beta Surveys at Engine Test Stand-1

A total of 50 square meters were surveyed at ETS-1. Figure 3-9 provides an overlay of the data on top of the site CAD drawing. Table 3-5 summarizes the data. There were no readings found above site reporting criteria.

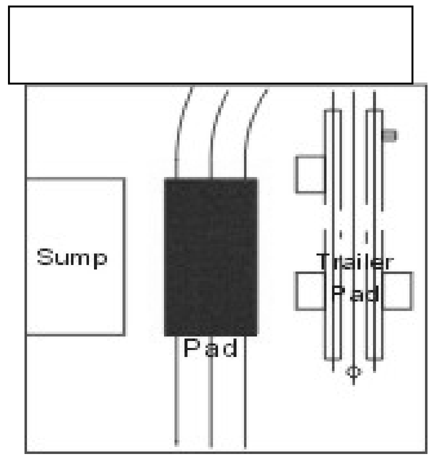

Figure 3-9 Overlay of Survey Results on Site Drawing ETS-1

Table 3-5 Beta Survey Summary: ETS-1

Survey Area	Maximum Concentration in any 100 cm^2 (dpm/100 cm^2)	Area (M^2)	Number of M^2 Exceeding Limit	Number of 100 cm^2 Areas Exceeding Limit	PSPC Efficiency
EST1B	7366.04	50	0	0	0.29

dpm = disintegrations per minute
cm^2 = square centimeters
m^2 = square meters

3.4 Alpha Surveys

The alpha surveys indicated limited contamination. The only area found to be above the site reporting criteria for alpha was R-MAD, particularly in the trench. Although alpha was found at Test Cell C, it was below reporting criteria. The data for the alpha surveys is presented in Tables 3-6, 3-7, and 3-8. The images for the surveys are not provided as the levels were typically below limits. The CAD overlay images from the beta surveys provide an indication of the area surveyed.

Table 3-6 Alpha Survey Summary: Test Cell C

Survey Area	Maximum Concentration in any 100 cm^2 (dpm/100 c ^{2})	Area (^{2})	Number of m^2 Exceeding Limit	Number of 100 cm^2 Areas Exceeding Limit	Highest μR/hr	PSPC Efficiency
CELLC1A	2,088	210	0	0	20	0.19
CELLC02A	2,438	260	0	0	24	0.18
CELLC03A	2,762	242	0	0	24	0.18
CELLC04A	1,862	262	0	0	49	0.18
CELLC05A	2,805	171	0	0	66	0.18
CELLC06A	2,245	118	0	0	103	0.18
CELLC07A	1,622	102	0	0	29	0.18
CELLC08A	2,033	112	0	0	21	0.18
CELLC09A	1,760	150	0	0	20	0.18
CELLC10A	1,395	144	0	0	20	0.18
CELLC11A	1,345	75	0	0	67	0.18
CELLC12A	1,560	120	0	0	19	0.18
CELLC13A	1,552	117	0	0	23	0.18
CELLC14A	2,675	108	0	0	27	0.18
CELLC15A	2,024	116	0	0	105	0.18
CELLC17A	1,239	33	0	0	105	0.18
CELLC18A	1,527	109	0	0	106	0.18
CELLC19A	1,247	199	0	0	78	0.18
CELLC20A	1,682	154	0	0	25	0.18
CELLC21A	1,940	147	0	0	20	0.18
CELLC22A	1,656	159	0	0	19	0.18
CELLC23A	1,562	172	0	0	19	0.18

dpm = disintegrations per minute
cm^2 = square centimeters
m^2 = square meters
μR/hr = microroentgens per hour

Table 3-7 Alpha Survey Summary: R-MAD

Survey Area	Maximum Concentration in any 100 cm^2 (dpm/100 c ^{2})	Area (^{2})	Number of m^2 Exceeding Limit	Number of 100 cm^2 Areas Exceeding Limit	Highest μR/hr	PSPC Efficiency
RMAD1A	1,715	76	0	0	17	0.18
RMAD2A	1,798	63	0	0	37	0.18
RMAD2AA	3,543	18	0	1	N/A*	0.40
RMAD3A	1,772	75	0	0	46	0.18
RMAD4A	1,660	74	0	0	32	0.18
RMAD4AA	6,435	15	0	3	N/A*	0.40

*Note: Surveys conducted with corner detectors do not contain Geiger-Mueller readings

dpm = disintegrations per minute
cm^2 = square centimeters
m^2 = square meters
μR/hr = microroentgens per hour

Table 3-8 Alpha Survey Summary: Engine Test Stand-1

Survey Area	Maximum Concentration in any 100 cm^2 (dpm/100 c ^{2})	Area (^{2})	Number of m^2 Exceeding Limit	Number of 100 cm^2 Areas Exceeding Limit	Highest μR/hr	PSPC Efficiency
ETS1A	1,026	52	0	0	16	0.18

dpm = disintegrations per minute
cm^2 = square centimeters
m^2 = square meters
μR/hr = microroentgens per hour

4.0 SYSTEM DESCRIPTION

4.1 SCM/SIMS Technology

Surveying and documenting of alpha, beta, and gamma contamination is an issue faced in man decontamination projects. Automated surveying systems that record and display data as collected, coupled with post survey computer processing of the collected data can enhance survey reliabilit and reduce survey costs. Using traditional radiation measurement techniques, the facility would be gridded into one-meter squares on both floors and walls and then handheld meters and smears would be used to measure radiation levels. Subsequently, the data is red uced and transferred to building drawings to map the results. Such a process is time consuming and allows for a technician's subjective observation during the process.

The SCM/SIMS system is commercially available through MSI. The system is past the demonstration stage and has been deployed in a variety of situations. Marketplace opportunities exist for the innovative technology at potentially radiologically contaminated sites in which remediation, D&D, or release activities are planned.

The innovative technology is not recommended for use in high-radiation/contamination areas, due to the sensitivity of electronic components and circuits. Also, the system demonstrated cannot be used for contamination detection on walls and ceilings (but the technolog could be adapted to do so). Due to physical size and geometry of the SCM, near corner and wall measurements can not be obtained in one pass; a secondary pass perpendicular to the first is needed. Rough surfaces and surfaces with protrusions present potential limitations and efficiency issues and would require additional planning and preparation.

4.2 Process Equipment

The SCM (Figure 4-1) and the associated SIMS are two distinct elements of this innovative technology that permit a radiation survey to be performed. The radiation detector is a gas -filled proportional counter. A total of 400 measurements are taken and recorded per square meter of surface area scanned (each measure ment corresponds to an area of 25 cm^2). An image of the contamination is generated and shown to the operator in real time while the monitor scans over the surface.

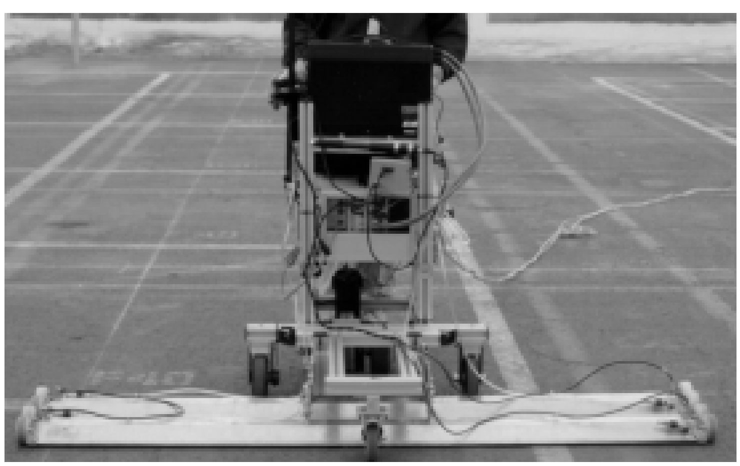

Figure 4-1 SCM Instrument used at NTS

The schematic for the SCM/SIMS system is shown in Figure 4-2. The SIMS can log data from the SCM, and the SIMS software can analyze data from a variety of detector systems for use with any data that are spatiall oriented. Digital imaging tools are included with the SIMS and allow for detailed studies to analyze for the presence of contamination. The SIMS allows import and export of data to various formats, including spreadsheets. These surveys are assembled into matrices of data using STITCHER©, a graphical code that permits the user to lay out and/or assemble strips graphically in the pattern in which the were run.

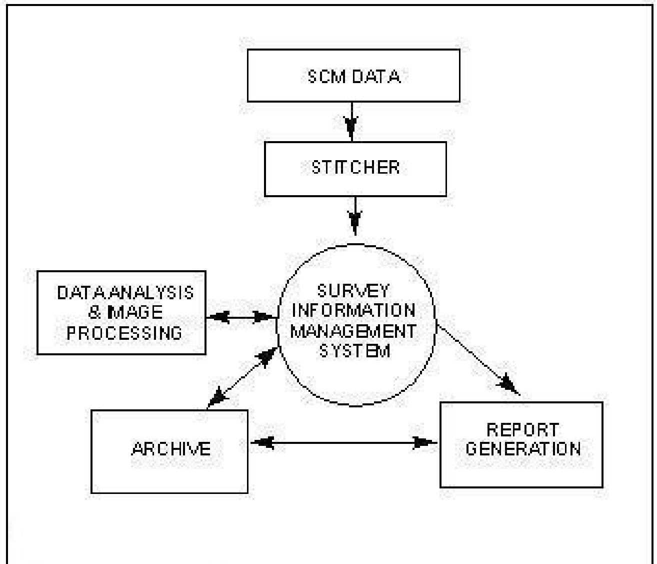

Figure 4-2 Simplified Process Schematic for the SCM/SIMS System

The SCM consists of a computerized PSPC deployed on a cart with a direct-current gear-motor drive. The detector differs from the conventional proportional counter used for surveying surface contamination in that the location of an event is measured in the counter. The detector is filled with P-10 gas (10 percent methane/90 percent argon).

The detector is a specialized type of proportional counter that includes an anode wire that collects gas ions. A sophisticated electronic circuit is used to determine if it was either an alpha or a beta particle, since the amount of ionization (hence, the proportional electronic pulse height) differs by a factor of approximately 10. The PSPC is a specialized type of proportional counter where each end of the anode wire is connected to its own preamplifier electronics. When the pulse of charge is collected on the anode wire, the charge divides and migrates down the anode wire to each preamplifier. If the initial charge is deposited in the middle of the counter, one-half of the charge will travel to each end of the counter. The pulse height at each end of the anode wire is measured for each pulse that occurs, and the location of the event is automatically calculated from the relative pulse heights.

4.3 Notable Capabilities

<u>SCM/PSPC</u>

- The PSPC detector can detect both alpha and beta/gamma radiation separately in the field without recalibrating the system.
- The system also can support a Geiger-Mueller detector for monitoring the general area radiation, a sodium iodide detector for gamma radiation (i.e., cesium-137, cobalt-60) and a field instrument detectors for low energy radiation (FIDLER) for transuranic gamma radiation, all with automatic mapping.
- The PSPC detector is adaptable to surveying walls, ceilings, or flat articles (e.g., laundry, sheet rock, and plywood), and for use as a portal monitor.
- Reports are automatically generated using a standard word processing program and include a two-dimensional color image of the contamination divided into a grid of one-m^2 blocks. A table beneath the image shows the minimum, maximum, average, and standard deviation of the average values for each block. Values for any block that exceeds release limits are displayed in bold font.

- The existing software and cart construction are flexible in that a variety of PSPC configurations and detectors can be used (see Figures 4-3 and 4-4).

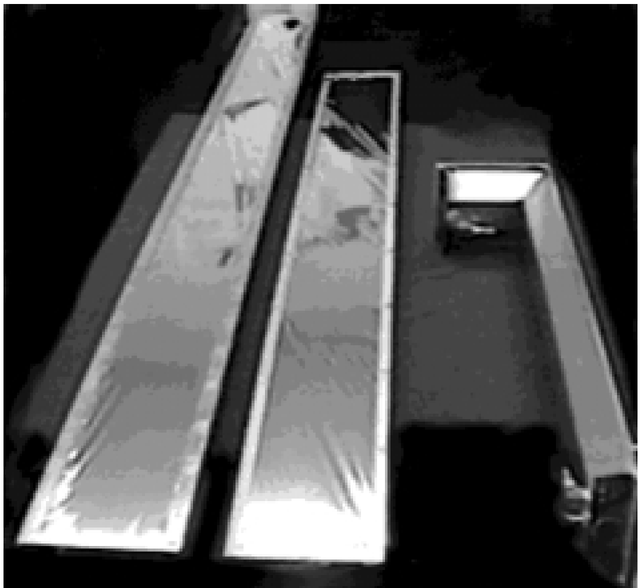

Figure 4-3 Different Detector Configurations

Figure 4-4 Detectors Supported by the SCM

SIMS

The SIMS embeds an analysis system called VISUSPECT© for studying the data. VISUSPECT© provides most of the mathematical treatments that the National Aeronautics and Space Administration developed for studying earth-imaging data sets. The SIMS also provides for segregating the survey data into square-meter blocks, with all relevant data reported for each block. This report provides a three-dimensional view of the data set and two-dimensional views that are split into blocks with a table indicating minimum, maximum, average, and standard deviations for the 400 measurements taken per square meter.

The SIMS can also provide output for other systems such as CAD and geographic information systems.

- A database electronic file is provided that includes every reading obtained with the date, time, file identification, reading(s), and coordinate information. The default coordinate system used is based on the local coordinate system for each survey with the origins at some arbitrary, identifiable location in the survey area, such as a corner.

- The direct-current gear motor, computer, and electronics can be powered from a 12-volt battery or normal wall plate (110 VAC), and the system has been operated from a portable generator.

5.0 SYSTEM OPERATION AND PERFORMANCE

5.1 SCM Operation

The SCM is computer controlled and executes under the Microsoft © disk-operating system. When the software is launched, the survey technician enters basic information such as the building and room name. This information is stored in a database associated with the survey. At this point, the SCM can be operated as a scanning machine. The survey technician decides on a se t of straight passes (called strips) that cover the area of interest. A sketch of the strips is used to document the location and identification of the strips. The computer logs the data in 5-cm by -cm (2-in. by 2-in.) increments as the system moves for ward. The data logging is initiated as the cart begins to move forward. At the end of the strip, the technician stops recording and relocates to the next strip.

The SCM does not need a collimator and can image the contamination in the same manner as a contact photograph because the detector is held in close proximity to the surface. The monitor software permits recording the data in a computer file that can be played back or can be used b SIMS.

5.2 SIMS Operation

The SIMS operation was deployed usin g the same computer that was used for the SCM, where the software is embedded in Microsoft Windows, 3.1©, and is written in C+ programming language. The SIMS can be loaded on a workstation that includes color printing, backup (either locally or through a local area network), a video player with time indexing, and a video capture board (to permit capturing useful video images into reports).

The survey is assembled into a pattern that reflects the pattern that the SCM used, by using STITCHER©. Using a computer mouse and the monitor screen, the user simply "grabs" strips, pulls them into location, and points them in the direction that they were taken.

After a survey has been stitched, another Windows © application, VISUSPECT© (which stands for visual insp ection) is run. The operator can automatically generate a report without having to transcribe numbers manually.

6.0 SYSTEM COST

6.1 Technical, Schedule and Cost Efficiencies

One of the major goals of the survey was to collect data to support assessmen t of the technical, schedule and cost efficiencies that could be attained through the use of the SCM/SIMS. Estimates for the cost of conventional surveys indicate that from $50 to $500 per square meter is expended on all program elements to perform and document surface contamination measurements with hand -held instrumentation. This section documents the time expended to perform and document the survey.

6.1.1 Planning and Approach

Historically, surface contamination surveys have utilized conventional ha ndheld instruments. Both characterization and release surveys have utilized handheld surveys at NTS. More recently, surveys have been designed based on statistical sampling techniques such as those performed in accordance with the requirements of the Multi-Agency Radiation Survey and Site Investigation Manual (EPA, 1997). The MARSSIM survey design is oriented to minimize the total measurements recorded to that needed to meet the survey Data Quality Objectives. This design philosophy is oriented to reduc ing the costs by reducing the number of samples needed, since many samples incur a high cost per sample. There was no consideration given to a MARSSIM approach in making this survey and comparison.

6.1.2 Survey Execution

For purposes of this deployment, the primary focus of the comparison between the handheld method and the SCM/SIMS technology focused on the survey portion of the facility life -cycle baseline. Those survey activities tracked and compared included: the beta and alpha surveys, instrument repairs, daily setup, data transfer, quality control, site administrative hold, site to site move, initial setup, demobilization, and other miscellaneous activities.

6.1.3 Report Generation

SIMS automates report generation. The computer -generated reports were made available in draft form for site personnel prior to the team's demobilization. This capability provides significant time and cost savings over that achieved with traditional methods. The data can be provided in both tabular form and in a variety of graphic forms as depicted in this report.

6.1.4 Survey Tim

The time required to conduct this survey was impacted by the level of effort required to support a first-of-a-kind survey. The survey was conducted in 6.5 days at the site. If a single S CM was deployed on a longer-term basis with a two or three man crew, a survey with comparable requirements could likely be completed in five working days.

The survey goals were designed to provide information about a large concrete pad at the Test Cel l C, and additional surveys for the R-MAD Decontamination Building and the ETS Decontamination Pad. The total area surveyed was 3,372 square meters for Test Cell C; 313 square meters for R -MAD; and 50 square meters for ETS, for a total of 3,735 square met ers. Since 90 percent of the area was at the Test Cell C, treatment of the total area and survey time as if it were from a single facility is appropriate. The data summarizes the total time spent on alpha surveys and on beta surveys without separating it out by facility.

The analysis of the data was documented in terms of execution time (hours) rather than man -hours. This was done in order to permit separation of the costs associated with surveys from factors that affected a one-time short duration survey. For example, the team lead could support two (or more) SCM crews. If two SCM systems were used for continuous use at one area, only one senior operator would be needed, and two junior operators (one per machine). To assess the costs, the hours show n for survey activities should be assessed as two staff needed for deployments of multiple SCM systems, and two to three staff for single SCM deployments

Table 6-1 identifies the categories of activities for the purposes of time comparison. The categorie s are defined as follows: Beta Survey; Alpha Survey; Repair; Daily Setup; Data Transfer; Quality Control; Site Administrative Hold; Site to Site Move; Miscellaneous; Initial Setup; and Demobilization.

Table 6-1 Comparison of Survey Time

Activit	SCM/SIMS Survey Time (hrs)	Handheld Survey Time per 100 M^3	Handheld Survey Time per 3,735 M^3
Beta Surve	13.8	12.5	467
Alpha Surve	18.7	12.5	467
Repair	2.7	1	38
Daily Setup	4.4	9	336
Data Transfer	9.8	29	1083
Quality Control	6.0	1.5	56
Site Administrative Hold	30.6	29.8	30
Site to Site Move	14.2	0	0
Miscellaneous	3.0	0	0
Initial Setup	4.9	9	9
Demobilization	3.3	8.5	8.5
Total Time	111.4	112.8	2,495

Alpha survey time was that time spent by the SCM/SIMS recording data while the instrument was set to the alpha plateau. Beta survey time was that time spent recording data on the beta plus alpha plateau. The SCM/SIMS beta survey was performed at twice the scan speed of the alpha survey (10 cm/s versus 5 cm/s). In both cases (alpha or beta SCM/SIMS survey), the time was established from the actual time stamps of the recorded data, and included time between files such as time spent moving the SCM to the next strip. The time shown under alpha and beta survey categories is about twice the time required to ro ll the total length of distance that the cart moved. In past surveys, MS has found that the "rolling efficiency" that can be attained on a survey is about 70 percent, with 30 percent of time needed to perform quality control checks, reposition equipment, prepare the surface, etc. The rolling efficiency was lower for this survey because the concrete was not smooth and level in all cases. At times, the cart was repositioned for the next strip of data by backing up to roll a strip in the same direction rather than go back and forth. This was needed when the concrete had a slope in order to provide the drive motor with a constant load so that the speed would be constant.

Other categories in Table 6 -1 that are needed on a continuing basis include quality c ontrol, dail setup, and data transfer. Initial survey activities encountered greater than normal breakage rates for detector windows due to debris and stubble on the surface. Under continuing surveys, such as the deployments of the SCM/SIMS at other DOE sites, detector repair is performed elsewhere and does not impact field effort. Because of the short schedule and breakage rate, repairs were effected in the field. The last five activities in the table would not occur for survey work of a continuing nat ure and therefore survey times for ongoing survey activities would be more cost efficient..

The largest category is administrative holds (Table 6-1). This category was dominated by two day of time for mandatory training and coordination prior to deploym ent to the site. There are requirements for daily tailgate safety meetings, dressing out in protective clothing and Radiological Control Technician support for the survey at R-MAD.

By comparison, the handheld survey (baseline technology) of 100 square meters was accomplished in about 113 hours. In the handheld surveys, both alpha and beta surveys were recorded at the same time so the survey time was split evenly for between the beta and alpha surveys. A breakdown of activit categories and survey time for both the 100 M^2 and the calculated time for the 3,735 M^2 is shown in Table 6-1. The major time differential between the handheld survey and the SCM/SIMS survey is in the data translation time.

6.1.5 Potential Cost Savings

If the handheld comparison s urvey had been conducted on all 3,735 square meters rather than onl 100 square meters, the total costs for a 100 percent handheld survey would have been about $162,000 for all survey elements. The SCM/SIMS survey resulted in costs of about $115,000. Cost savings to perform this survey occurred primarily in the areas of alpha and beta surveys and data transfer/report generation. The cost savings was $47,000 but could have been as much as $77,000 for a facilit survey of the size completed in this deployme nt, depending on the amount of surface preparation time. This represents a cost saving of at least 40% over the handheld methodology.

7.0 REGULATORY/INSTITUTIONAL ISSUES

7.1 Regulatory Considerations - The SCM/SIMS system is an investigation tool for characterizing contaminated surfaces; therefore, no special regulatory permits are required for its use. The detection level of the SCM/SIMS system meets the requirements of 10 CFR Parts 20 and proposed Part 834, which make this system appropriate for free-release surveys.

7.2 Safety, Risk, Benefits, and Community Reaction

Worker Safety

- Normal radiation protection, worker safety procedures used at the facility would apply.
- Technology users should implement contamination control practices.
- Since the PSPC uses P-10 gas supplied by an on-board, small, pressurized cylinder, precautions for airborne contamination should be considered when the instrument is used in areas with loose surface contamination.
- Normal electrical grounding requirements should be met when using 110-VAC power.
- Normal precautions with lead-acid storage batteries apply.

Community Safety

- There is no adverse impact on community safety.

7.3 Environmental Impact

- It is not anticipated that implementation of this innovative technolog would present any adverse impacts to the environment.

7.4 Socioeconomic Impacts and Community Perception

- No socioeconomic impacts would be expected in association with use of this technology.

- Public perception of this technology should be positive as it enhances the quality of information available upon which regulators and the public base cleanup decisions.

8.0 SCHEDULE

The DOE EM Office of Science and Technology partnered with DOE/NV in this ASTD project with EM-50 providing $85K of funding. DOE/NV committed an additional $85k to the ASTD project. Deployment of the SCM/SIMS at NTS was performed per the following schedule:

ACTIVITY	PROPOSED SCHEDULE	ACTUA PERFORMANCE
Procurement	June 1999	September 1999
Training	September 1999	October 1999
First Deployment	October 1999	October 20, 1999
Second Deployment	December 1999	October 27, 1999
Survey Report	April 2000	April 2000
Evaluation Report	June 2000	June 2000

9.0 OBSERVATIONS AND LESSONS LEARNED

9.1 Key Deployment Results

This innovative system was successfully deployed at the NTS with the following key results:

- Accurately correlated contamination levels to specific locations as evidenced by hot spot verification using the baseline
- Acquired and stored continuous radiological data in database format
- Provided clear, concise, comprehensible graphics of survey data
- Costs using the innovative technology were significantly less than baseline costs

9.2 Lessons Learned from the Deployment at NTS

The results at NTS confirmed the above benefits of this technology. There were a number of lessons learned identified during the deployment at NTS including the following:

- Site preparation – All surfaces to be surveyed require complete removal of small rocks, weeds, and surface debris and the surfaces should be swept prior to starting surveys. Surface preparation increases survey speed and reduces the potential for detector damage; however, the increased exposure potential from airborne contaminates due to sweeping should be considered.

- Starting location – The radiation monitoring should be started in the area that potentially has the highest contamination levels first. This provides timely health and safety information and ensures contamination levels are as expected.

- Cart design – The SCM-4 cart with the capabilities to survey walls as well as floors and pads created some difficulty in keeping the detectors flush to the surface particularly on flat surfaces. The SCM-1 cart design would improve survey speed and reduce measurement errors from the detector coming up off the ground for horizontal surveys.

- Calibration sources – Large area NIST traceable sources would provide enhanced calibration for the PSRM.

- Handheld instruments – The use of the PSRM requires handheld instruments to support locating and marking hot spots identified by the PSRM. The continuous survey provided by the PSRM does not allow time for the operator to identify the exact location of contamination. Some additional development of a mechanism to mark hot spots detected during the survey would enhance the process of pinpointing the location for cleanup during remediation.

- Data reports – The automatically generated survey reports generated by the SIMS are significant to the efficiency of the technology as deployed at NTS. The automatically generated surve reports did not clearly identify the type of survey being represented (e.g., alpha or beta survey). The survey report falsely indicates 0 dpm per 100 cm minimum surface activity for the survey area when incomplete survey grids are included. This was manually correlated during data analysis.

- Topology – Application may be limited on floors or pads with curvature or uneven surfaces. Pads that are not flat but curved do not allow constant distance between the detectors and the surface being surveyed.

9.3 Implementation Considerations

- To effectively perform a survey, obstacles should be cleared from the floor or minimized to the extent possible. Even though the system can be maneuvere d around the obstacles by using a smaller detector size, the main benefit of using the larger length detectors is that overall surve time is reduced.

- Additional caution is required to prevent damaging the PSPC window when the system is operated over rough surfaces (e.g., gravels, vegetative stubble, or outdoor surfaces), particularl with alpha measurements.

- The deployment at NTS demonstrated the efficiency of the technology for large, exterior, concrete surfaces.

- Considering the instrument sensitivit to surface conditions, i.e., undulating surface or debris resulting in variances of detector to surface distance, alpha detection may need confirmator measurements with a handheld detector.

9.4 Technology Limitations/Needs for Future Development

- Due to physical size and geometry of the PSPC, near corner and wall measurements could not be obtained in one pass; a secondary pass perpendicular to the first was needed. Near corner and wall measurements may also be accomplished by changing to a detector with a right angle.

9.5 Technology Selection Considerations

- The technology is suitable for DOE nuclear facility D&D sites or any other sites requiring surface characterization. It is particularly useful for property transfer or site release where DOE desires to turn the site over to the private sector without restrictions.

- The technology is useful for site characterization in support of D&D engineering design, as well as during and post-D&D activities.

- Reports can be generated automatically that provide a clear, concise, and understandable representation of the exact locations and concentrations of contamination. The data can be used for job planning and decontamination activities, as well as input to dose assessment software packages. Obtaining the data is quicker than the baseline, and the resulting data set is more accurate, complete, and reproducible than the baseline technology.

- All information acquired with the system is scientifically derived and is not subject to subjective observations of a technician. The data are electronically logged and are not recorded manually, reducing the propensity for error.

10.0 LITERATURE

10.1 References

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10.2 Related Publications

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- Experiment 97-03-001, Calibration of the PSPC for Sr/Y-90

- Experiment 97-03-002, Calibration of the PSPC for Tl-204

- Experiment 97-03-003, Measurement of the alpha plateau for SCM

- Experiment 97-03-004, Calibration of the PSPC for Tc-99

- Experiment 97-03-005, Calibration of the PSPC for Th-230

- Experiment 97-03-006, Determination of calibration parameters for LND 7807 GM tube when coupled to ESP-II

- Experiment 97-03-007, Determination of calibration parameters for 3x3 NaI crystal installed in collimation assembl

- Experiment 97-03-008, Calibration of the PSPC for Cs-137

- Experiment 97-03-009, Calibration of the PSPC for Th-232

- Experiment 97-03-010, Determination of calibration parameters for Bicron G5 FIDLER

- Experiment 97-03-011, Post survey confirmation of SCM calibration in support of operations at Hanford